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UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

OFFICE REPORT

BALSAM WOOLLY APHID TREND PLOTS IN SUBALPINE AND GRAND FIR
Installation Records and Summary of Plot Data
1959 to 1961

By

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INTRODUCTION

Since discovery of the current balsam woolly aphid (Chermes piceae Ratz.) outbreak in 1954, several trend plots have been installed to study the relationships of the aphid to its true fir hosts. The first study, a cooperative project between the Pacific Northwest Forest and Range Experiment Station and Weyerhaeuser Company on mortality trends of infested Pacific silver fir, has been in progress since 1954 and is now being summarized for formal publication. A second study, started by the Station in 1959, has been concerned with the installation and annual examination of three trend plots in subalpine fir and two plots in grand fir. The purpose of this report is to discuss these five trend plots; more specifically, to (1) present the objectives of the trend study, (2) provide a historical record of the plot locations and stand characteristics, (3) describe how and what data is collected, and (4) summarize and record effects and characteristics of aphid infestations noted to date.

STUDY OBJECTIVES

Objectives of the trend plot study in infested subalpine and grand fir stands are:

1. To determine how fast balsam woolly aphid populations develop on subalpine and grand firs and how rapidly trees are killed.

2. To determine the pattern of tree killing within stands.

3. To determine if stand characterisitics and site differences effect intensity and severity of balsam woolly aphid infestations.

4. To determine the tree symptoms of imminent mortality in subalpine and grand fir stands.

PLOT LOCATIONS AND METHODS OF INSTALLATION

In selecting areas for plot installation, the aim was to (1) find stands in the early stages of infestation--stands with active balsam woolly aphid populations but showing little mortality, and (2) duplicate the plots in areas with different site and stand characteristics. Once an area was selected, a center line for a strip-type plot was arbitrarily projected through whatever portion of the stand seemed most representative of the site. Length and width of the plot was determined by the number of trees per unit area, the objective being to record at least 200 trees spread over a moderately long strip. Accordingly, widths of the strips varied from 200 feet in sparse stands to 100 feet in dense stands.

Once a center-line was established, with cedar stakes placed at 50-foot intervals, all true firs above a 2.0" DBH and within a predetermined distance (50 to 100 feet) of either side of the center line were marked with numbered aluminum tags. Tags were nailed at head height on the sides of the trees facing the center line. After tagging, each tree was mapped and measured for DBH.

Plots were numbered in 1, 2, 3, order according to the year they were installed. Their locations are:

Alpine fir plot 1 - Installed September 9-12, 1959, by P. E. Buffam and J. N. Owens, 2.2 miles east of Salt Creek Falls tunnel on U.S. Route 58 (Willamette Pass Highway); 100 feet on south side of highway. Legal description: Sec.3, T.23 S., R.5-1/2 E., W.M. (See map in Appendix A.).

Alpine fir plot 2 - Installed August 2-3, 1960, by J. N. Owens and R. G. Mitchell, 0.3 miles east of plot 1 and 160 feet north of U.S. Route 58. Legal description: Sec.3, T.23 S., R.5-1/2 E., W.M. (See map in Appendix A.).

Alpine fir plot 3 - Installed June 26-27, 1961, by R. L. Johnsey and R. G. Mitchell, about 1 mile east of Hoodoo ski bowl junction on U.S. Route 20 (Santiam Pass Highway); plot located on the south side of the highway in the immediate area where the Skyline Trail crosses the highway. Legal description: S.E.1/4 of Sec.19, T.13 S., R.8 E., W.M. (See map in Appendix B.).

Grand fir plot 1 - Installed August 4, 1960, by J. N. Owens and R. G. Mitchell, approximately 1 mile southeast of Monroe, Oregon, on south side of Long Tom River. Legal description: S.W.1/4 of Sec.34, T.14 S., R.5 W., W.M. (See map in Appendix C.).

Grand fir plot 2 - Installed June 28, 1961, by R. L. Johnsey and R. G. Mitchell, approximately 4.5 miles northwest of Junction City, Oregon, on U.S. Route 99W.; located just north of the northeast corner of Washburn State Park (Benton-Lane Park). Legal description: N.E.1/4 of Sec.12, T.15 S., R.5 W., W.M. (See map in Appendix D.).

RATING PROCEDURE AND DATA TAKEN

Early fall (about October 1) was selected as the best time for examining the five trend plots. Then, crown discolorization from aphid damage is greatest, and aphid populations are at peak densities. Field glasses are used to evaluate individual trees and data is recorded on 5- by 8-inch forms (Appendix E.). Using two men, rating time varies from 10 to 16 man hours per plot.

Some of the same kinds of data, such as crown class, crown exposure, and intensity and location of stem infestations, are recorded for both grand and subalpine fir. Additional recordings are: Subalpine fir--top kill in tenths and percent gouting; grand fir--presence or absence of top curling and old foliage density. Keys to the two rating systems are presented in Appendices F and G.

DESCRIPTION OF TREND PLOT STANDS

Characteristics of the five subalpine and grand fir stands encompassed by trend plot boundaries are summarized in table 1.

Table 1.--Characteristics of stands on subalpine and grand fir trend plots

Plot	Ave. 1/ tree age	Ave. dbh of dom. & codom.	Approximate elevation of plots	True firs per acre	Canopy	Estimated species composition
	Years	Inches	Feet	Ave. No.		
Alpine fir 1 (3.58 acres)	98.2	18.3	4,000	105	Open	5% Pacific silver fir 50% Subalpine fir 45% Engelmann spruce
Alpine fir 2 (0.80 acres)	108.6	8.9	4,000	275	Open	1% Noble fir 1% Pacific silver fir 75% Subalpine fir 23% Mtn. hemlock
Alpine fir 3 (0.34 acres)	55.3	9.2	4,500	648	Closed	1% Grand fir 4% Engelmann spruce 95% Subalpine fir
Grand fir 1 (0.46 acres)	25.5	7.9	300	447	Closed	75% Grand fir 25% Douglas-fir
Grand fir 2 (0.80 acres)	28.9	9.4	300	146	Closed	25% Grand fir 75% Douglas-fir

1/ In each stand except grand fir plot 1, average age was determined from some 40 randomly-selected increment cores. Average age on the grand fir plot was calculated from 240 borings.

Alpine fir plot 1 is located on a wet site adjacent to a large swampy, alpine meadow. The forest floor is characterized by many depressions and hummocks and is covered with a dense mat of mesophytic to hydrophytic type plants, notably Solomon's seal (Smilacina sessivolia), wood lilly (Trillium ovatum), skunk cabbage (Lysichitum americanum), bunch-berry (Cornus canadensis), and some blue huckleberry (Vaccinum sp., uliginosium?). Alpine fir plot 2 is on a dry, gently sloping south aspect, about 600 feet uphill from the creek bottom. The forest floor is largely bare, supporting only a few xerophytic type plants such as squaw-grass (Xerophyllum tenax) and manzanita (Arctostaphylos sp., patula?). Alpine fir plot 3 is located just east of the Cascade summit on a gently rolling, southeast facing slope. The site is somewhat dry although more moist than plot 2. Few plants grow under the dense overstory. In open places, the predominant plant species is a species of huckleberry, probably Vaccinium deliciosium.

Grand fir plot 1 is located on a gently north sloping bench area, about 100 feet from the Long Tom River. Plot 2 is situated in a level area immediately adjacent to a large open pasture. The two stands occupy similar sites, characterized by heavy clay, moderately drained soils. Both would probably be designated as agricultural land, although somewhat marginal. Few plants grow under the dense overstories, but openings support heavy growth of blackberry (Rubus macropetalus), poison-oak (Rhus diversiloba), and bracken fern (Pteridium aquilinum).

SUMMARY OF PLOT DATA

Data recorded on the five subalpine and grand fir trend plots from 1959 through 1961 are summarized in tables 2 through 9, Appendix H. Because this is the first summary since the plots were established, some of the tables, particularly the last five, are quite bulky and appear unduly repetitious. The data, however, will be useful in final summary; hence the detail. Not summarized is information on gouting and old foliage density which as yet has shown nothing of significance.

Plot records have not been kept long enough to predict long-term trends. However, a few infestation characteristics are evident thus far. One characteristic is the pattern of bole infestations. On subalpine fir at Willamette Pass (trend plots 1 and 2) infestations start high in the trees and work progressively downward, with gouting most severe in the tops. On the other hand, infestations in grand fir and the subalpine fir at Santiam Pass (trend plot 3) start on the lower stem and move upwards; hence, there is little top kill. However, with grand fir, after a couple years of heavy stem infestation, the last 5 to 10 years of top growth develop a distinctive droop, the appearance of which suggests a shepherd's staff. Such top-curling occurs even though the bole infestation is usually 10 to 20 feet below the level of the crook.

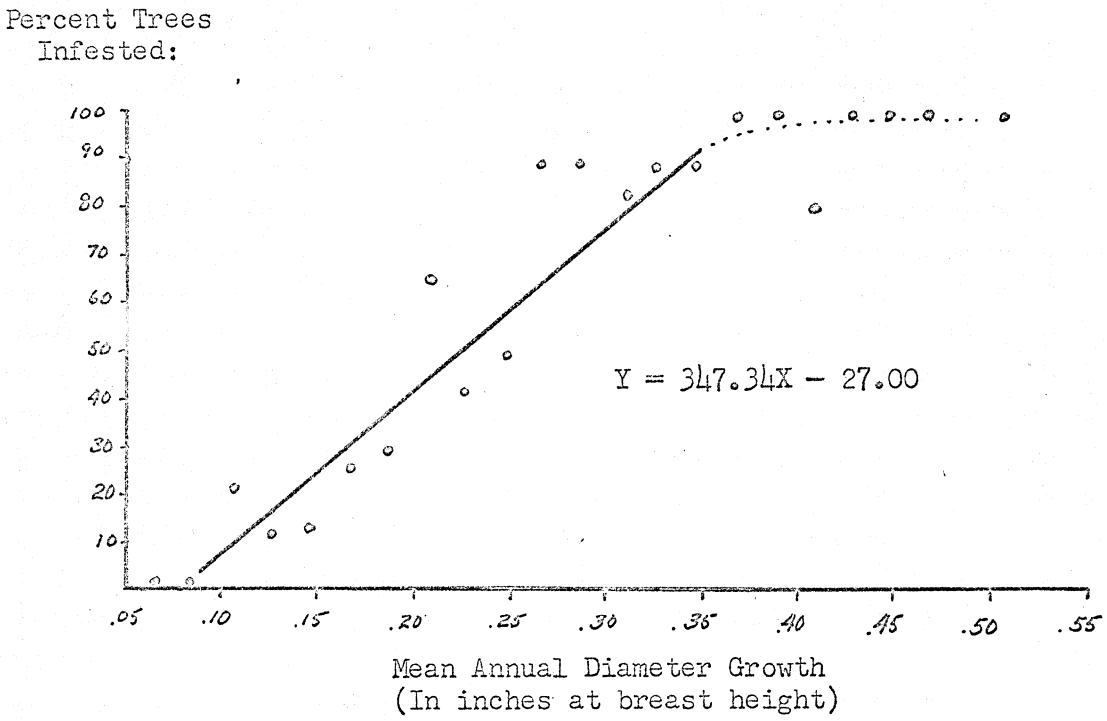
Another feature of aphid infestation noted on both grand and subalpine firs during the course of this study is a strong tendency for the balsam woolly aphid to select the largest, most vigorous trees in the stand. This is especially apparent in the early stages of infestation. To determine the significance of this observation, a correlation test was made on grand fir trend plot 1. The test consisted of comparisons, for each plot tree, of tree age and mean annual diameter growth with the presence or absence of bole infestation.

Results of the test showed both host age and rate of diameter growth significantly correlated with frequency of infestation; the older the tree and the faster its growth, the more likely it was to be infested with the balsam woolly aphid. These relationships are shown graphically in figure 1.

It is evident from figure 1 that both age and growth rate are important factors relating to susceptibility of grand fir to aphid infestation. It is not apparent, however, that the two factors differ in significance. At a given age, regardless of whether the tree is young or old, growth rate is the more significant factor from the standpoint of predicting whether a tree will become infested or not. When both variables were equated in a multivariate analysis (Appendix H), the regression coefficients were 0.30 for age and 2.99 for growth.

To determine if the above information has practical value, an attempt was made to use both age and growth rate for predicting infestation probability. This was done by applying the statistics obtained in the multivariate analysis to a discriminant function formula.1/ Results showed that infested trees on grand fir plot 1 could have been predicted with a probability of one mistake in six tries.

1/ $Y = X_1 + 95.75\ X_2$. Key: X_1, host age (years); X_2, mean annual diameter growth (inches). Trees attaining Y-values greater than 47.7 are susceptible to aphid attack and those with lower values are not.



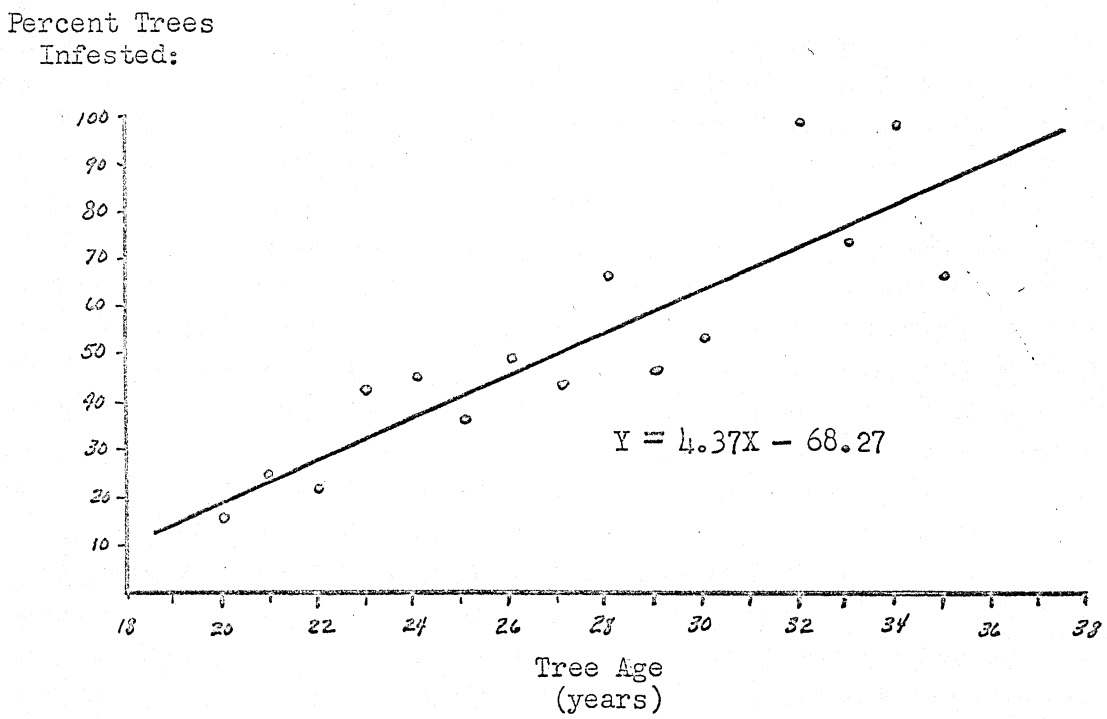
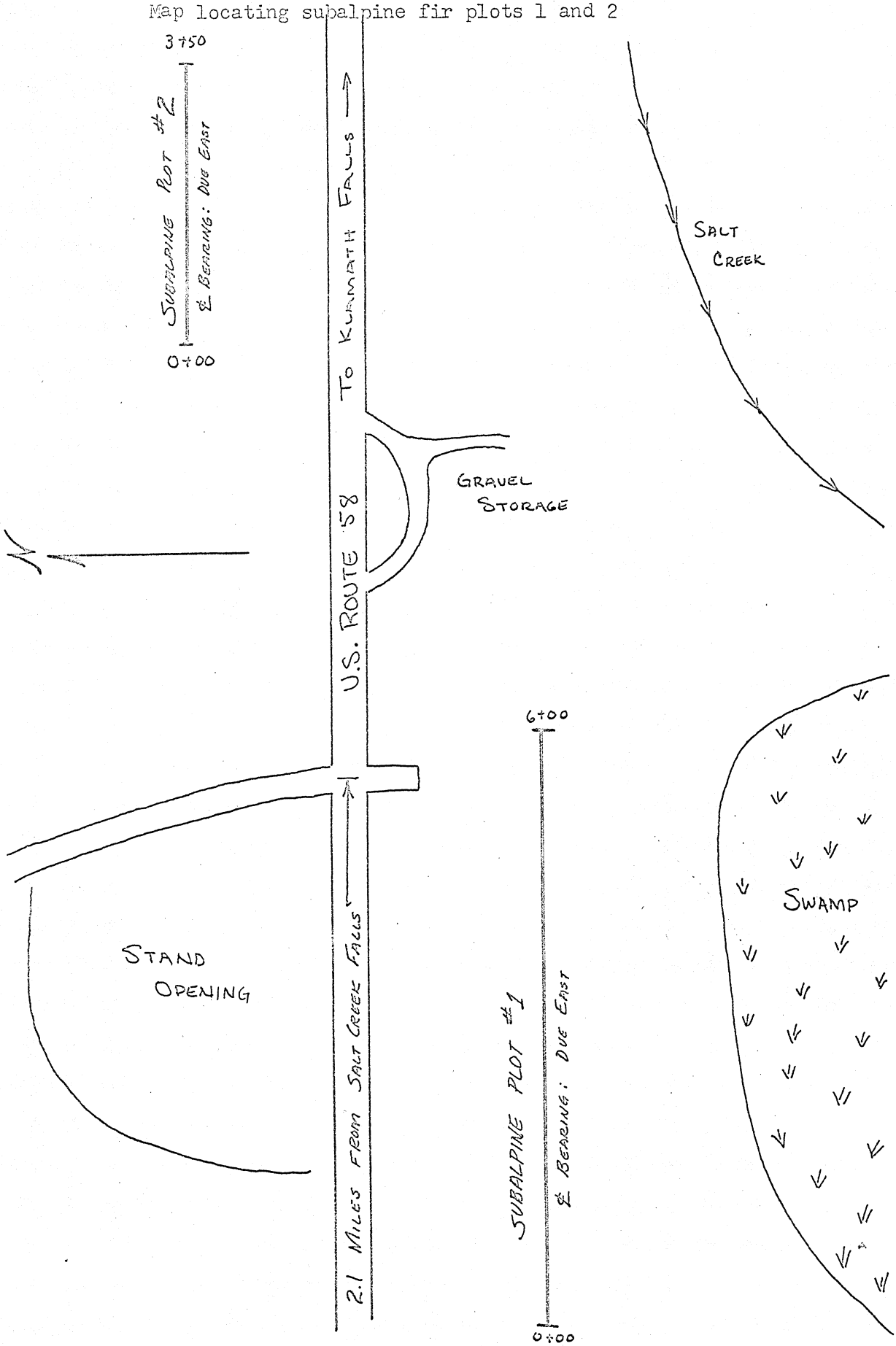


Figure 1. Relationship between grand fir susceptibility to the balsam woolly aphid and host growth rate and age.

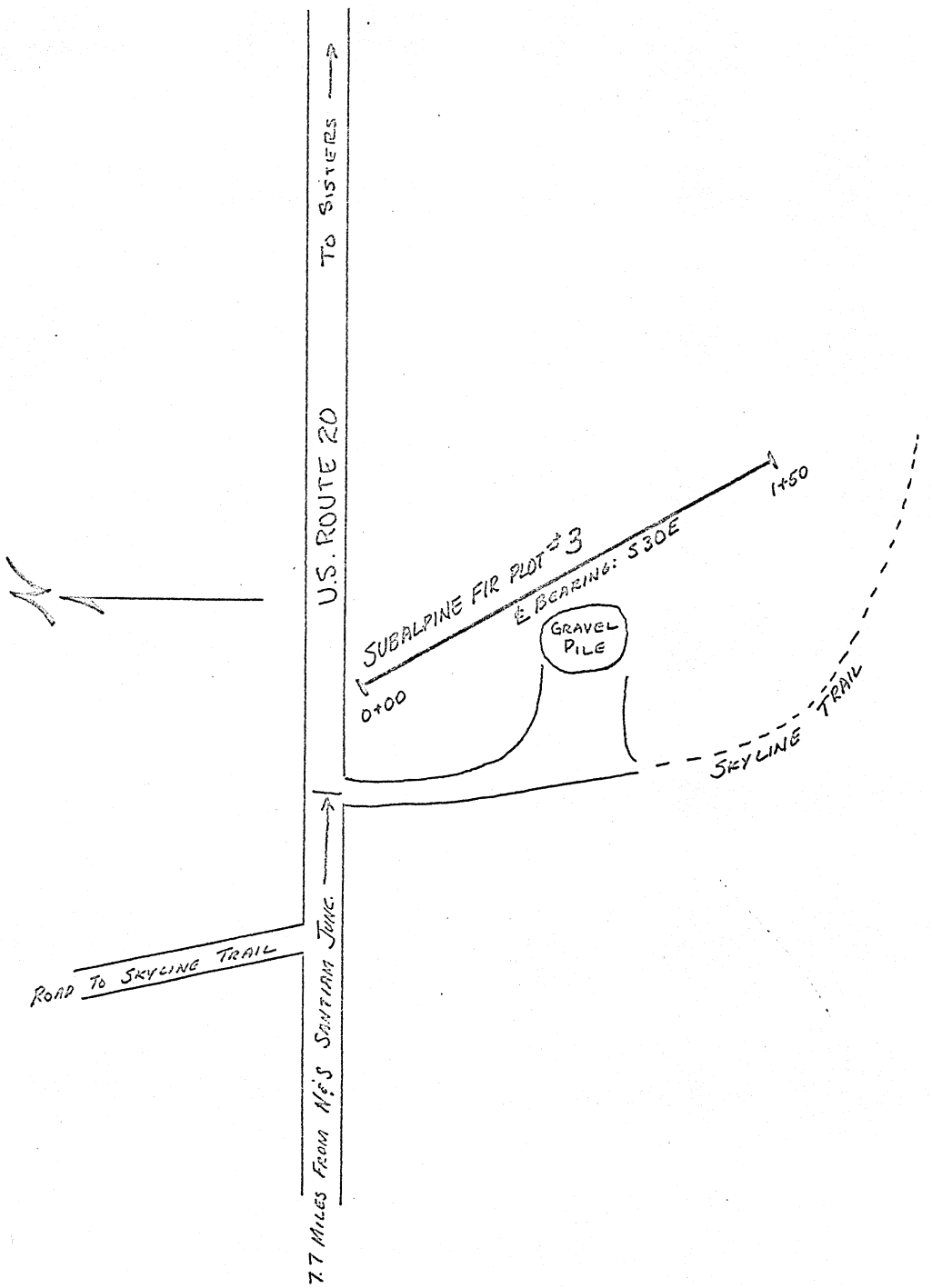
APPENDIX A

Map locating subalpine fir plots 1 and 2



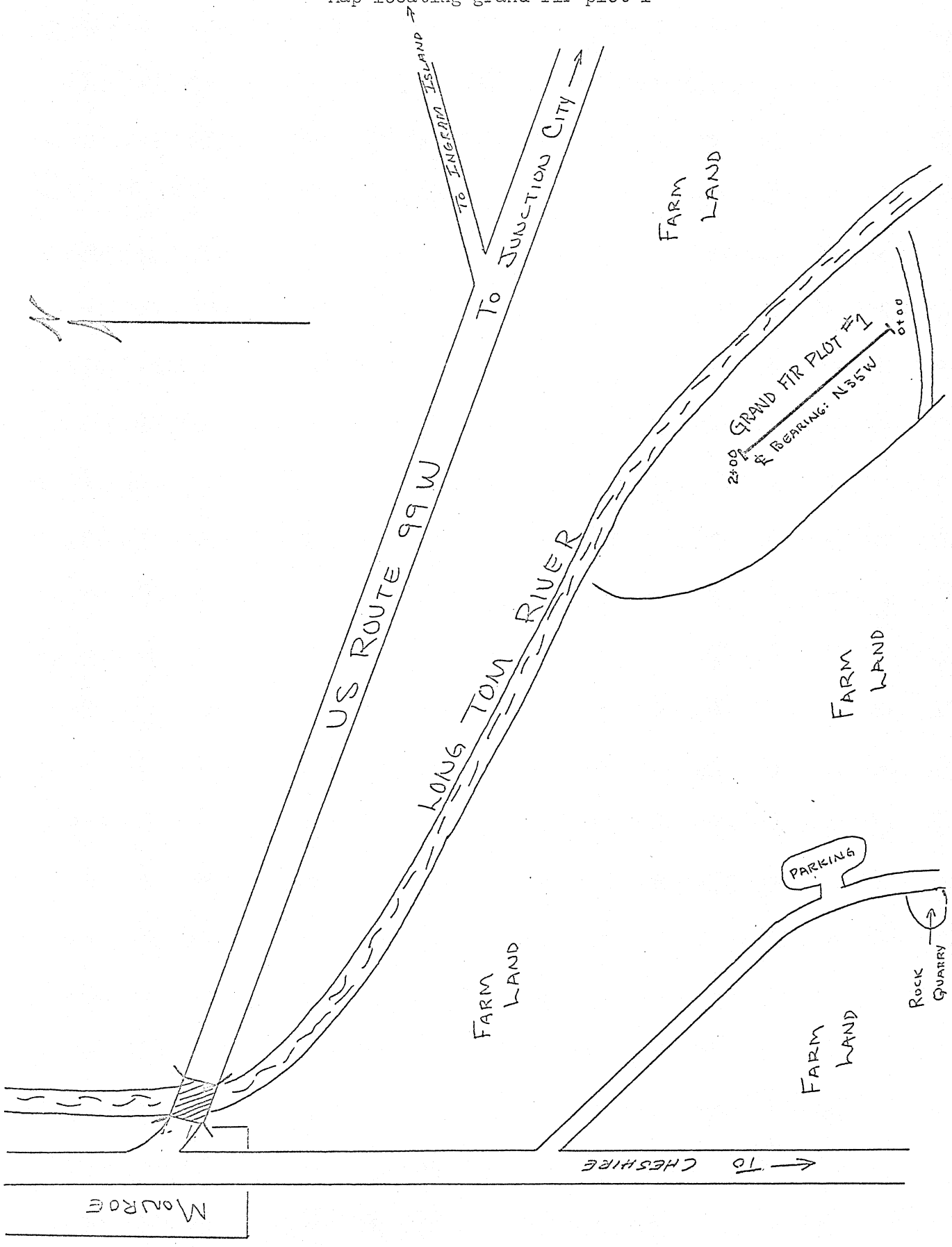
APPENDIX B

Map locating subalpine fir plot 3



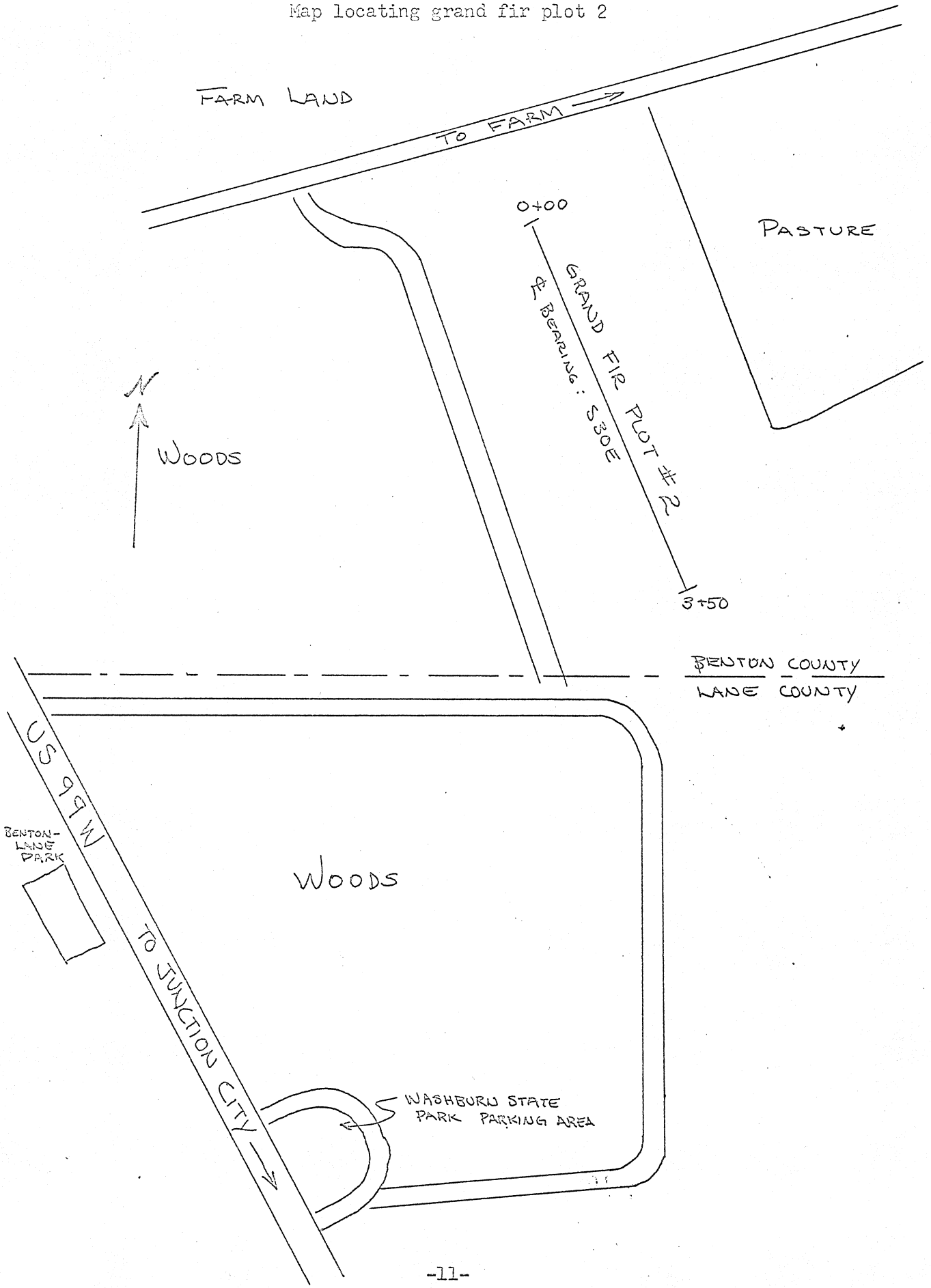
APPENDIX C

Map locating grand fir plot 1



APPENDIX D

Map locating grand fir plot 2



APPENDIX E

Form for recording trend plot data

CHERMES TREND PLOT TREE EVALUATION FORM FIR 61

Tree No._____ Location_____

Tree Species_____ Tree Age_____

D.B.H._____ Dom._____

Date of Exam.	Topkill	Bole Infestation		Gouting	Exposure	Exam. by	Remarks
		A	B				

APPENDIX F

Key for data collected on individual subalpine firs

1. Diameter: In inches and tenths

2. Crown Class:

   D - Dominant

   CD - Codominant

   I - Intermediate

   S - Suppressed

3. Top kill: In tenths of live crown killed

4. Bole Infestation: By location: A - upper half; B - lower half

   1 - (light) - 1 to 10 sistens/ sq.ft.

   2 - (moderate) - 11 to 288 sistens/sq.ft.

   3 - (heavy) - more than 288 sistens/sq.ft.

5. Gouting: In upper 1/2 of crown only

   1 - (light) - 1 to 33% of twigs gouted

   2 - (moderate) - 34 to 67% of twigs gouted

   3 - (heavy) - 68 to 100% of twigs gouted

6. Exposure

   1 - Full light from above and sides

   2 - Full light from above, partial from sides

   3 - Light from above or 1 side only

   4 - Over-topped; no direct from above or sides

APPENDIX G

Key for data collected on individual grand firs

1. Diameter: In inches and tenths

2. Crown class: (same as Appendix F)

3. Top: Erect, curled, or broken out

4. Bole infestation: (same as Appendix F)

5. Old foliage density:

    1 - (slightly sparse) - 1 to 33% absent

    2 - (moderately sparse) - 34 to 67% absent

    3 - (extremely sparse) - 67 to 100% absent

6. Exposure: (same as Appendix F)

APPENDIX H

Table 2.--Average DBH, distribution of crown classes, and average crown exposure of subalpine and grand firs on five trend plots

Plot	Ave. DBH	No. of trees in each crown class 1/				Ave. exposure 2/
		Dom.	Codom.	Inter.	Supp.	
Subalpine 1	8.2	3	31	60	137	2.8
Subalpine 2	5.2	1	43	120	56	2.8
Subalpine 3	6.4	13	68	68	69	2.8
Grand 1	5.8	33	93	75	41	2.7
Grand 2	6.7	19	43	35	26	2.8

1/ Trees dead at plot establishment not included.

2/ See key to exposure in Appendix F.

Table 3.--Top kill recorded on subalpine fir plot #1 1/

Year	No. of trees with top kill, by tenths			Total no.of top killed trees	Percent top killed trees dying the following year
	1/10-3/10	4/10-6/10	7/10-9/10		
1959	31	5	0	36	38.9
1960	35	8	5	48	41.7
1961	52	4	3	59	-

1/ Trees on the other four trend plots have insignificant top kill.

Table 4.--Annual mortality on five subalpine and grand fir trend plots

Plot	Year	No. of trees dead	Ave. DBH (inches)	Remarks
Subalpine 1 (270 alpine fir, 20 silver fir)	Before 1959	22	9.2	About 10 dead from chermes, the rest from unknown causes
	1959	19	11.8	All dead from chermes
	1960	40	8.2	31 dead from chermes; 1 from suppression; 8 from suppression and chermes; 11 with top kill the year prior to death
	1961	28	9.8	26 dead from chermes; 2 from suppression and chermes; 18 with top kill the year prior to death
Subalpine 2 (217 alpine fir, 2 silver fir, 1 noble fir)	Before 1960	4	8.3	3 dead from chermes; 1 from wind break
	1960	2	7.0	Both dead from chermes
	1961	1	6.5	Dead from chermes; no prior top kill
Subalpine 3 (218 subalpine fir)	Before 1961	6	5.4	3 dead from suppression; 3 from unknown reasons
	1961	16	5.3	7 dead from chermes (Ave. dbh.:6.9"); 8 from suppression; 1 from unknown cause
Grand fir 1 (242 grand fir)	Before 1960	1	10.7	Dead from chermes
	1960	3	3.7	All dead from suppression
	1961	13	3.8	2 dead from chermes (ave.dbh.:9.3"); 10 from suppression; one from vandalism
Grand fir 2 (124 grand fir)	Before 1961	0	-	-
	1961	2	9.3	Both dead from chermes

Table 5.--Subalpine fir plot 1: Distribution of trees according to stem infestation ratings in 1959, 1960, and 1961

Year	Infestation intensity on lower stem		Infestation intensity 1/ on upper stem				Total	
			3	2	1	0	No.	%
			No. trees					
1959	3		86	1	0	0	87	34.9
	2		48	22	0	5	75	30.2
	1		14	12	16	16	58	23.3
	0		1	2	2	24	29	11.6
	Total	No.	149	37	18	45	249	100.0
		%	59.8	14.9	7.2	18.1	100.0	
1960	3		104	0	2	0	106	50.7
	2		26	1	1	0	28	13.4
	1		26	7	7	13	53	25.4
	0		2	1	2	17	22	10.5
	Total	No.	158	9	12	30	209	100.0
		%	75.6	4.3	5.7	14.4	100.0	
1961	3		95	1	0	0	96	53.0
	2		21	3	1	1	26	14.4
	1		21	4	5	10	40	22.1
	0		2	2	2	13	19	10.5
	Total	No.	139	10	8	24	181	100.0
		%	76.8	5.5	4.4	13.3	100.0	

1/ See Appendix F for key to intensity ratings.

Table 6.--Subalpine fir plot 2: Distribution of trees according to stem infestation ratings in 1960 and 1961

Year	Infestation intensity on lower stem		Infestation intensity on upper stem				Total	
			3	2	1	0	No.	%
			------- No. trees -------					
1960	3		20	0	0	0	20	9.3
	2		16	2	1	0	19	8.9
	1		57	16	15	7	95	44.4
	0		18	11	18	33	80	37.4
	Total	No.	111	29	34	40	214	100.0
		%	51.9	13.6	15.9	18.6	100.0	
1961	3		46	1	0	0	47	22.1
	2		28	4	2	1	35	16.4
	1		40	23	12	4	79	37.1
	0		18	4	6	24	52	24.4
	Total	No.	132	32	20	29	213	100.0
		%	62.0	15.0	9.4	13.6	100.0	

Table 7.--Subalpine fir plot 3: Distribution of trees according to stem infestation ratings in 1961

Year	Infestation intensity on lower stem		Infestation intensity on upper stem				Total	
			3	2	1	0	No.	%
			------ No. trees ------					
1961	3		5	4	5	4	18	9.2
	2		3	3	4	10	20	10.2
	1		2	3	17	57	79	40.3
	0		0	0	11	68	79	40.3
		No.	10	10	37	139	196	100.0
		%	5.1	5.1	18.9	70.9	100.0	

Table 8.--Grand fir plot 1: Distribution of trees according to stem infestation ratings in 1960 and 1961

Year	Infestation intensity on lower stem		Infestation intensity on upper stem				Total	
			3	2	1	0	No.	%
			------- No. trees ------					
1960	3		1	5	13	14	33	13.9
	2		2	2	6	13	23	9.6
	1		2	2	2	49	55	23.1
	0		0	0	0	127	127	53.4
	Total	No.	5	9	21	203	238	100.0
		%	2.1	3.8	8.8	85.3	100.0	
1961	3		0	3	8	34	45	20.0
	2		1	0	1	26	28	12.4
	1		0	2	1	55	58	25.8
	0		0	0	0	94	94	41.8
	Total	No.	1	5	10	209	225	100.0
		%	0.4	2.2	4.4	92.8	100.0	

Table 9.--Grand fir plot 2: Distribution of trees according to stem infestation ratings in 1961

Year	Infestation intensity on lower stem		Infestation intensity on upper stem				Total	
			3	2	1	0	No.	%
			------- No. trees ------					
1961	3		1	0	3	17	21	17.2
	2		0	0	0	21	21	17.2
	1		0	1	0	31	32	26.2
	0		0	0	3	45	48	39.3
		No.	1	1	6	114	122	100.0
		%	0.8	0.8	4.9	93.5	100.0	

APPENDIX I

Analysis of variance table for a multivariant test showing the effects of age and growth on the susceptibility of grand fir to balsam woolly aphid attack

Source of variation	Degrees freedom	Sum of squares	Mean square	F
Total variation	237	59.23		
Accounted for by age and growth	2	30.92	15.46	128.30**
Accounted for by age alone	1	4.16		
Left for growth after the effect of age has been removed	1	26.76	26.76	222.07**
Accounted for by growth alone	1	28.13		
Left for age after the effect of growth has been removed	1	2.79	2.79	23.15**
Error	235	28.31	0.1205	

** Significant at the 1 percent level.